SECTION 6 - pH

SUMMARY

As a result of the 1998-1999 SWQB/NMED monitoring effort in the Jemez River Basin, several exceedances of New Mexico water quality standards for pH were documented on Sulphur Creek. Figures 5.A.1 and 5.A.2 in Section 5 show the land use/cover and land ownership percentages for the segment of Sulphur Creek listed for this constituent (Sulphur Creek above Redondo Creek to the headwaters). A detailed description of this segment is provided in Subsection A, Section 5 of this document.

Photo 17. Sulphur Creek (NMED Sampling Station 12 – Thermograph T9)

ENDPOINT IDENTIFICATION

Target Loading Capacity

Overall, the target values are determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator; and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document the target value for pH is based on numeric criteria, which is consistent with the State's antidegradation policy.

pH

According to the New Mexico water quality standards (20.6.4.108 NMAC), the State's standard leading to an assessment of use impairment is the numeric criterion stating that "pH shall be within the range of 6.6 to 8.8" for the appropriate designated use as a High Quality Cold Water Fishery (HQCWF). This use is not fully supported on Sulphur Creek as discussed in this section.

Flow

pH in a stream can vary as a function of flow. As flow decreases, the concentration of total dissolved solids (TDS) can increase, thereby increasing the pH. Similarly, as flows decline, temperatures have a tendency to increase, thus affecting pH values. This TMDL is calculated at a specific flow rate.

When available, US Geological Survey gages are used to estimate flow. Where gages are absent geomorphological cross sectional information is taken at each site and the flows are modeled or calculated. In this case, gaged streamflow data is not available for Sulphur Creek. Cross sectional data were taken by SWQB staff in order to estimate stream discharge using procedures from USGS Technical Paper 2193, *Streamflow Characteristics Related to Channel Geometry of Streams in Western United States*, (USGS, 1983). The resulting field data from this survey for Sulphur Creek are presented at the end of this section.

Following USGS procedures (USGS, 1983), average annual discharge is calculated using the following regression equation:

$$Q_A=64W_{ac}^{1.88}$$

where,

Q_A = acre-feet/yr and W_{ac} = width of the active channel (width at bankfull) in feet

Utilizing the cross section at the end of this section, the width of Sulphur Creek at bankfull is 4.0 feet. The flow calculations are shown below:

$Q_A = 64(4.0)^{1.88}$
$Q_A =$ 867.1 acre feet/year
$Q_A =$ 1.2 cfs
$Q_A =$ 0.776 MGD

Average annual discharge is defined as that flow rate which if continued every day of the year, would yield the observed annual volume of water. The average annual discharge usually fills a channel to approximately one-third of the channel depth, and this flow rate is equaled or exceeded approximately 25% of the days in a year (Leopold et al. 1964).

Average discharge is characterized by five attributes, which make it ideal for TMDL modeling:

1. Approximately 75% of the time, flows are less than the average discharge.
2. Volume carried by these flows amounts to only 25% of the annual volume.
3. It can be easily modeled.
4. It is the discharge average for 365 days (one year).

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained; meeting the calculated target load may be a difficult objective.

Calculations

To date, there is no established or proposed procedure for evaluating waterbodies that require TMDLs for pH in the State of New Mexico. Consequently, the following procedure was adapted from a TMDL written for Hopkins County, Kentucky. A draft of this report titled "Total Maximum Daily Load (TMDL) Development – pH (H^+ Ion Mass) – for Cane Run Watershed: (KDEP, 2001) can be found on the website http://www.water.nr.state.ky.us/dow/Cane_Run.pdf.

A target load for pH is calculated based on a flow rate, the current water quality standard, and a unit-less conversion factor, 8.34, that is used to convert mg/L units to lb/day (see Appendix A for conversion factor derivation).

This target load was computed based on the allowable minimum pH value (6.6) for creeks and streams used for recreation and aquatic life. Because the standard units for pH do not allow for the computation of a quantitatively useful load or reduction amount, the TMDL was computed in grams of ions and subsequently converted to pounds per day.

The relationship between hydrogen ion load and pH can be expressed as follows:

$$\{H_3O^+\} = 10^{-pH} \text{ or more commonly } \{H^+\} = 10^{-pH}$$

where pH is the negative log of the H^+ ion activity in moles/liter. The pH can be converted to a mole/liter measurement (i.e. moles [H^+]/liter) by applying the following relationship:

$$pH = -\log\{H^+\}$$

The resulting moles of hydrogen is the anti-log of -6.6, which is 0.00000025 moles/liter.

The units need to be converted into mg/L, and because the atomic weight of hydrogen is 1 gram per mole, the concentration of hydrogen ions in mol/L is also the concentration in g/L as shown by the calculations below.

$$0.00000025 \text{ moles/liter x 1 gram/mole} = 0.00000025 \text{ g/L x } 1000 = 0.00025 \text{ mg/L}$$

The target load (TMDL) predicted to attain standards was calculated using Equation 1 and is shown in Table 6-1.

Equation1.

Flow (MGD) x Standard (mg/L) x 8.34 (conversion factor) = Target Loading Capacity

Therefore, for any given flow rate, there is a maximum ion load that the stream can assimilate before a minimum pH value of 6.6 is violated. Thus for any given day, a TMDL may be calculated using the average daily flow and a minimum pH standard of 6.6 units.

Table 6-1: Calculation of Target Loads

Location	*Flow (MGD)	Standard pH (mg/L)	**Conversion Factor	Target Load Capacity (lb/day)
Sulphur Creek	0.776	0.00025	8.34	0.00162

*Since a USGS gage was unavailable on this reach, the flow is modeled using the cross-sectional data (included at the end of this section) that are used to estimate stream discharge using USGS Technical Paper 2193 (USGS, 1983).
**Conversion factor used to convert mg/L to lb/day (See Appendix A).

Background loads were not possible to calculate in this sub-watershed. A reference reach, having similar stream channel morphology and flow, was not found. It is assumed that a portion of the load allocation is made up of natural background loads. In future water quality surveys, finding a suitable reference reach will be a priority.

The measured loads were similarly calculated. In order to achieve comparability between the target and measured loads, the flows used were the same for data that exceeded the standards. The geometric mean of these exceedances was subsequently converted to units of mg/L and substituted for the standard in Equation 1. The measured load calculations are as follows:

Measured pH = 4.18 (Geometric mean of exceedances)

The resulting moles of hydrogen is the anti-log of -4.18, which is 0.000066 moles/liter.

Thus,

(0.000066 moles/liter x 1 gram/mole = 0.000066 grams/L x 1000 = 0.066 mg/L

The pH data collected for Sulphur Creek are located in Table 6-6 at the end of this section. The same conversion factor of 8.34 was used. Results for measured loads are presented in Table 6-2.

Table 6-2: Calculation of Measured Loads

Location	*Flow (MGD)	**Measured pH (mg/L)	***Conversion Factor	Measured Load (lb/day)
Sulphur Creek	0.776	0.066	8.34	0.427

*Since a USGS gage was unavailable on this reach, the flow is modeled using the cross-sectional data (included at the end of this section) that are used to estimate stream discharge using USGS Technical Paper 2193 (USGS, 1983).
**The geometric mean of field measured pH exceedances (Table 6-6) converted to mg/L.
***Conversion factor used to convert mg/L to lb/day (See Appendix A).

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*
There are no point source contributions associated with this TMDL; therefore, waste load allocation is zero.

•*Load Allocation*
In order to calculate the Load Allocation (LA), the waste load allocation (WLA) and margin of safety (MOS) were subtracted from the target capacity (TMDL), as shown below in Equation 3.

Equation 3. $WLA + LA + MOS = TMDL$

Results are presented in Table 6-3.

Table 6-3: Calculation of TMDL for pH

Location	WLA (lb/day)	LA (lb/day)	MOS (25%) (lb/day)	TMDL (lb/day)
Sulphur Creek	0	0.00121	0.00041	0.00162

The load reduction that would be necessary to meet the target load was calculated to be the difference between the load allocation (Table 6-3) and the measured load (Table 6-2), and is shown in Table 6-4.

Table 6-4: Calculation of Load Reduction for pH

Location	Load Allocation (lb/day)	Measured Load (lb/day)	Load Reduction (lb/day)
Sulphur Creek	0.00121	0.427	0.426

Identification and Description of Pollutant Source(s)

Pollutant sources that could contribute to Sulphur Creek are listed in Table 6-5.

Table 6-5: Pollutant Source Summary

Pollutant	Magnitude (WLA + LA + MOS)	Location	Potential Sources (% from each)
Point: None	0	--------	0
Nonpoint: pH	0.00162	Sulphur Creek	100% Unknown & Natural

LINK BETWEEN WATER QUALITY AND POLLUTANT SOURCES

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDLs requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED, 1999). The Pollutant Source(s) Documentation Protocol, shown as Appendix B, provides an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 6-5 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment.

In previous studies, it was observed that the ion load tends to increase as a function of flow, reach a maximum, and then decrease as the flow increases. It is hypothesized that these results reflect two competing physical processes. At lower flows, it is hypothesized that ion loads are initially leached out of source areas resulting in increasing ion loads. A maximum value of ion load is reached and as the runoff volume increases, it is hypothesized that the ion loads in the source areas become depleted and therefore reduced because of flow dilution in the stream. As a result, ion load increases with increasing flow, reaches a maximum, then decreases as the flow continues to increase (KDEP, 2001).

MARGIN OF SAFETY (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for the nonpoint sources the margin of safety is estimated to be an addition of 25% for pH for the TMDL, excluding background. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*
A level of uncertainty exists in sampling nonpoint sources of pollution. Accordingly, a conservative margin of safety increased the TMDL by 15%.

•*Errors in calculating flow*

Flow estimates were based on estimated mean average annual discharge using cross-sectional information found in Table 6-6, at the end of this section (SWQB/NMED field data) and USGS Technical Paper 2193 (USGS, 1983). To be conservative, an additional MOS of 10% will be included to account for accuracy of flow computations.

CONSIDERATION OF SEASONAL VARIATION

Data used in the calculation of this TMDL were collected during spring, summer, and fall of 1998 in order to ensure coverage of any potential seasonal variation in the system. It is assumed that if the critical conditions are met, coverage of any potential seasonal variation will also be met.

FUTURE GROWTH

Estimations of future growth are not anticipated to lead to a significant increase for pH that cannot be controlled with best management practice implementation in this watershed.

Table 6-6: pH Results During 1998-1999 Sampling Effort

STATION 12 - SULPHUR CREEK		
SAMPLING DATE	**MEASURED pH VALUE**	**MEASURED TDS VALUE (mg/L)**
4/20/1998	* 4.14	188
4/21/1998	* 4.55	152
4/22/1998	* 4.87	170
4/23/1998	* 5.42	146
7/13/1998	* 3.54	484
7/13/1998	7.77	512
11/2/1998	* 3.03	472
GEOMETRIC MEAN OF THE EXCEEDANCES--->	4.18	233.5

* Exceedance

SURVEY DATA ⟹ CROSS - SECTION Part 1

SITE: Sulphur Above Redondo Date:

Location:

Party / Notes:

Distance; Point; or STATION Ft.	Back-Sight B S Ft.	Height of Instrument H I Ft.	Fore-Sight F S Ft.	Height; Depth; or Elevation Ft.	NOTES COMMENT REMARKS

Cross-Section

Distance	Adjusted Distance	Height	Adjusted Height	Notes	
					Pin
					ROB
41.0	0.0	6.18	100.00	LBP	Break slope
34.0	7.0	6.95	99.23		Flood Plain
27.0	14.0	7.02	99.16		BF
26.6	14.4	8.46	97.72		
24.0	17.0	8.56	97.62	LBF	
22.3	18.7	9.29	96.89		
21.3	19.7	9.80	96.38	Thalwag	Max depth
20.6	20.4	9.59	96.59		
20.0	21.0	8.56	97.62	RBF	BF
17.0	24.0	8.28	97.90		
16.0	25.0	6.76	99.42		
8.0	33.0	6.07	100.11		
0.0	41.0	5.72	100.46	LBP	

41.0 6.18

max depth 1.2

4' wide BF

9.4

7.4 26-

16

26-?? Flood ??

8.6 18-?

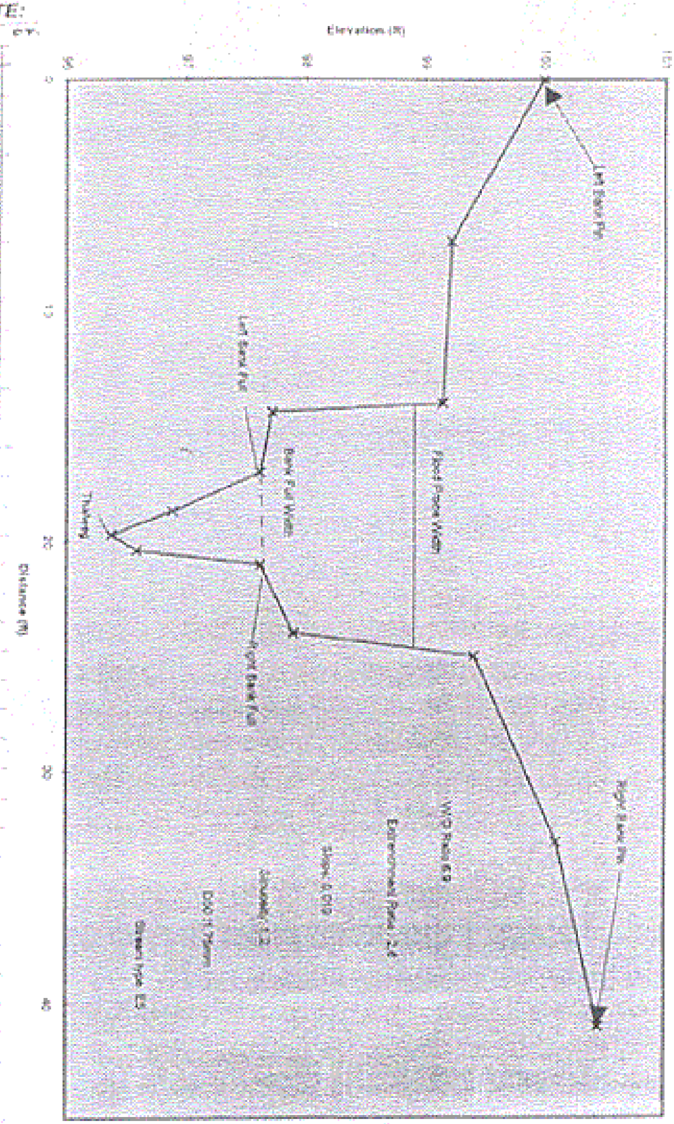
1.2 10-3

7.9

upstream Elev 6.36 .02

low Elev 10.16

200ft



THE REFERENCE REACH FIELD BOOK

SURVEY DATA ⟹ LONGITUDINAL PROFILE — Part I

SITE: SULPHUR ABOVE REDONDO

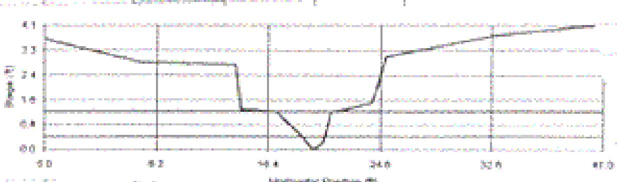
Date:

Location:

Party / Notes:

Distance; Point; or STATION ft	Back-Sight B S ft	Height of Instrument H I ft	Fore-Sight F S ft	Height; Depth; or Elevation ft	NOTES / COMMENT / REMARKS

Resistance Equation: Thorne and Zevenbergen



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THE REFERENCE REACH FIELD BOOK

SURVEY DATA ⟹ LONGITUDINAL PROFILE — Part II

SITE:

Date:

Item	STATION ft	B S ft	H I ft	F S ft	Elevation ft	NOTES / COMMENT / REMARKS
36						
37						
38						
39						
40						
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